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A VECTOR AUTOREGRESSIVE MODEL OF SAUDI ARABIAN INFLATION

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I. Introduction

Saudi Arabia is, arguably, the single most important actor in the determination of world oil prices.[1/] As the world's largest oil exporter, Saudi Arabia, given its small population, has been able to play the "balance wheel" or to operate as the "marginal producer" in the global oil price setting system. However, Saudi behavior is at least partially predicated on the impact of world economic pressures on the Saudi economy. Global inflation or recession may eventually lead to internal pressures on the Saudi government, pressure that has at least occasionally been relieved by changing oil prices and/or production.

It has also been widely recognized that oil prices have likely had a major impact on both U.S. and global real gross domestic product (GDP).[2/] In addition, many studies have shown that oil prices have had potentially major impacts on both U.S. and global inflation.[3/]

Given the importance of Saudi Arabia in the determination of world oil prices and given the importance of oil prices on world inflation and world GDP, the structure of the Saudi economy becomes an issue of much greater significance than one would expect for most nations of similarly sized real gross domestic product.

In this paper we are primarily interested in trying to model Saudi inflation. It would be reasonable to expect that the Saudi government would respond to whatever variable was perceived to be causing the most severe internal economic difficulties. Cleron (1978) has argued that during the mid- and late 1970's inflation was the most serious problem in the Saudi economy. Thus, Saudi governmental policies would be aimed largely at controlling Saudi inflation.

Government economic policies in Saudi Arabia could include the traditional mix of fiscal and monetary policies. However, both Saudi fiscal and monetary policies are largely derived from oil revenues. Thus, it makes more sense to talk of "oil policy" which would include traditional fiscal and monetary policy tools. From the expenditure side, Alam (1982) has argued that revenues from oil sales when those sales are increasing will tend to have an inflationary impact on an oil-based economy such as Saudi Arabia. In addition, the most common methods of disbursement of government oil revenues in Saudi Arabia tend to increase the money stock which is also generally considered inflationary.

A number of efforts have been made to econometrically model Saudi inflation. Past studies of Saudi inflation can be divided into those which have focused solely on inflation, for example, Keran and Al-Malik (1979) and Rosser (1983), and those which have focused on a more general model, for example, Al-Bashir (1977), Cleron (1978) and Zanoyan (1980). The results of both the single equation studies, as well as the more general modeling efforts, have been ambiguous. For example, Keran and Al-Malik (1979), including only lagged currency and a global inflation index in an inflation equation, found that their measure of the money supply was the more important independent variable. Rosser (1983) found a number of significant independent variables in his inflation equation including an import price index, government loans for agriculture and housing production (a supply-side stimulus) and the money supply. The money supply, however, appeared in only a marginally significant role, while import prices appeared to be the most important variable. In contrast, Al-Bashir (1977) found money was the only significant explanatory variable of Saudi inflation, while an import price index was insignificant.

This paper represents an effort to combine aspects of both the single equation and the system approaches to examining Saudi inflation. In this paper we develop a small model of the Saudi economy, paying attention to institutional characteristics, and focusing on the implications for Saudi inflation. The methodology employed is vector autoregressive (VAR) analysis of this system of several macro variables. The VAR procedure allows a more detailed and realistic examination of the reduced form relationships occurring within the Saudi economy than is possible in a single equation framework. The model presented here, however, is much smaller in scale than the large-scale models mentioned above. By considering smaller scale vector autoregressive models we retain enough degrees of freedom to compare alternate specifications and to more completely examine alternate lag structures.

The model used here contains five variables: the Saudi consumer price index (CPI), Saudi money supply (M1), Saudi exports, Saudi crude oil prices and a Saudi import price index. The empirical results below suggest the following direct relationships: inflation is a function of both money and import prices; money is dependent on exports; exports are determined by oil prices and by import prices; oil prices are functions of Saudi inflation and import prices; and import prices are dependent on oil prices. Due to the complexity of the lag structure in the vector autoregressive system one cannot ascertain all the causal relations between variables solely from the estimated equations. Each variable potentially has impacts on all others, if only indirectly. Thus, the total relationships between variables, both direct and indirect, are more appropriately analyzed by examining model simulations.[4/] The model simulations reported below imply that oil price changes and import price changes have the greatest total impacts, direct plus indirect, on the Saudi economy in general and on inflation in particular. In contrast, monetary changes have had much less impact over the period under consideration. In Section II we briefly outline the vector autoregressive methodology. Section III presents the estimated equations, alternate specifications and model simulations. Section IV details some implications for the Saudi economy, while Section V presents a summary and some remaining limitations.

II. VAR Techniques

Vector autoregressive techniques have recently been extensively discussed.[5/] Thus, the specific methodology employed here will be presented in abbreviated form.

In this section it is assumed that all variables are stationary series. To achieve stationarity all series employed below are the first differences of natural logs. The analysis begins with a set of reduced form equations of the form:

$$(1) \quad \begin{bmatrix} P \\ O \\ I \\ M \\ X \end{bmatrix} = \begin{bmatrix} a_{11}(L) & a_{12}(L) & a_{13}(L) & a_{14}(L) & a_{15}(L) \\ a_{21}(L) & a_{22}(L) & a_{23}(L) & a_{24}(L) & a_{25}(L) \\ a_{31}(L) & a_{32}(L) & a_{33}(L) & a_{34}(L) & a_{35}(L) \\ a_{41}(L) & a_{42}(L) & a_{43}(L) & a_{44}(L) & a_{45}(L) \\ a_{51}(L) & a_{52}(L) & a_{53}(L) & a_{54}(L) & a_{55}(L) \end{bmatrix} \cdot \begin{bmatrix} P \\ O \\ I \\ M \\ X \end{bmatrix} + \begin{bmatrix} u_1 \\ u_2 \\ u_3 \\ u_4 \\ u_5 \end{bmatrix}$$

where the a_{ij}'s are the estimated coefficients; the L indicates a lag operator; and the variables are defined as follows:

$P \equiv$ Saudi consumer price index,

$O \equiv$ Saudi crude oil price index,

$I \equiv$ Saudi import price index,

$M \equiv$ the Saudi money supply and

$X \equiv$ total Saudi imports.

All the series except I were taken from International Financial Statistics. The import price index series was interpolated from an annual series found in the Hijra 1401 Annual Report of the Saudi Arabian Monetary Agency (SAMA).[6/] Equations were estimated over the period 1969 to 1980 using quarterly data.[7/] It should also be noted that all data are probably subject to a steadily improving degree of accuracy over the course of the observation period.

The above system of equations represents the most general model possible, given our choice of included variables. Anderson, Johannes and Rasche (1983) have demonstrated that time series methods and structural econometric models both involve the imposition of constraints on a system of equations such as above. Some constraints, such as the requirement of finite lag lengths, are necessary simply to permit estimation. The technique employed here, following Hsiao (1981, 1982) and Caines, Keng and Sethi (1981), permits testing of at least some of the constraints imposed.

We begin by estimating a sequence of autoregressions for each of the variables in the system:

$$(2)\quad Y_{i,t} = \alpha_0 + \sum_{r=1}^{R} \alpha_r Y_{i,t-r} + \varepsilon_t$$

where R is sequentially increased from one to ten. The maximum lag length, here ten quarters, must be specified a priori. Akaike's final prediction error (FPE) criterion is then used to determine the appropriate lag length and thus the appropriate value for R. The original lag lengths specified should be generous to avoid imposing inappropriate restrictions. (With five variables this procedure implies estimating fifty equations.)

The next step is to sequentially add variables to the five equations chosen in the above step. For example, the equation

$$(3) \quad Y_{i,t} = \alpha_0 + \sum_{r=1}^{R} \alpha_r Y_{i,t-1} + \sum_{s=1}^{S} \beta_s Y_{j,t} + \varepsilon_t$$

is estimated where R is now fixed from the previous FPE and S is sequentially increased from one to ten as above. Again, the maximum lag length S is specified a priori. Equations of this form are estimated for all $i \neq j$. The equations finally chosen are again those which minimize the FPEs. (For each of the five dependent variables there are sequentially ten lags of each of the four other variables for a total of 200 equations.) This process is repeated, adding variables to the above preferred equations as required. (There are at most 300 additional equations required.)

When this process has been repeated until no further improvement in the FPE is possible, then the individual equations are collected into a system of equations that is deliberately overfit and underfit, and the standard diagnostics such as the F statistics are calculated to ascertain the overall goodness of fit of the estimated model. The model is deliberately overfit and underfit to guard against the model selection being determined in part by the ordering of inclusion of the variables. Of course, in a model of this size it is impossible to test all possible specifications. In general, in a system of n variables with a maximum lag length of order R on all variables, there would be $n(R+1)^n$ different model specifications. In this example there are roughly 150,000 possible specifications. While we do not undertake a comprehensive search, the procedure employed here searches the likelihood function in a relatively efficient manner, although it cannot, of course, guarantee a global minimum. This point is examined in more detail below.

It should be noted that the VAR analysis is a reduced form technique. Thus, it is difficult to ascertain the underlying structural relationships from the estimated equations. However, as Fischer has noted, vector autoregressive analysis is ". . . a convenient way of summarizing empirical regularities and perhaps suggesting the predominant channels through which relations work." That will be its use here.

III. Estimation Results

In selecting an appropriate model the FPE test was used to determine a preliminary estimate of the appropriate lag length as mentioned above. Alternate specifications were then compared using standard F-tests to determine the final equation specifications. These final equations are presented in the appendix. Again, the limitations on the interpretation of the estimated coefficients should be kept in mind. The results are summarized below in equation (4) where the values in parentheses indicate the final estimates of the lag lengths.

Equation (4) is simply the final estimated form of the general representation given by equation (1).

$$(4)\quad \begin{bmatrix} P \\ O \\ I \\ M \\ X \end{bmatrix} = \begin{bmatrix} 0 & 0 & a_{13}(1) & a_{14}(2) & 0 \\ a_{21}(5) & a_{22}(1) & a_{32}(6) & 0 & 0 \\ 0 & a_{32}(4) & a_{33}(1) & 0 & 0 \\ 0 & 0 & 0 & a_{44}(4) & a_{45}(9) \\ 0 & a_{52}(5) & a_{53}(6) & 0 & a_{55}(1) \end{bmatrix} \cdot \begin{bmatrix} P \\ O \\ I \\ M \\ X \end{bmatrix}$$

A summary of some of the overfitting and underfitting tests is presented in table 1. We briefly focus on the estimated equations and the overfitting and underfitting specification tests.

Saudi inflation is apparently directly determined by Saudi import prices and by Saudi money growth. These results should not be surprising. The Saudi economy is an open economy and is significantly influenced by world inflation as it spills into the Saudi economy in terms of higher imported prices. In addition, an increase in Saudi money growth leads to additional inflation. While individual coefficients and coefficient sums must be interpreted with care in any VAR, it should be noted that the sum of the estimated coefficients on money in the inflation is significantly less than one.

The specification tests in table 1 suggest that the restriction that the coefficients on oil prices, a_{12}, are equal to zero and the restriction that the coefficients on exports, a_{15}, are equal to zero cannot be rejected. However, the restriction that either the import price coefficients or the money coefficients can be restricted to equal zero can easily be rejected.

The specification tests reported in table 1 represent a subset of the specification tests actually undertaken. For example, alternate combinations of the zero restrictions were tested as well as restrictions on coefficients corresponding to alternate lag lengths on the right-hand-side variables. In the inflation equation the tests were uniform in concluding that imports and money were significant, while other variables were insignificant. This finding that the specification results were not sensitive to lag length or to the inclusion/exclusion of other variables generally was true for all equations.

The oil price equation implies that Saudi oil prices are influenced by Saudi inflation and Saudi import prices. The Saudis have consistently stated when increasing oil prices that those increases have been prompted in part because of world inflation. The oil price equation suggests that those statements are accurate. Higher world inflation, as seen from the Saudi perspective in terms of their import prices, has led to higher oil prices. In addition, higher Saudi inflation has also had a direct impact on oil prices. Neither Saudi money nor Saudi exports have any direct impact on Saudi oil prices in the context of this model. Again, the specification tests indicate that the restrictions that the coefficients on the excluded variables are equal to zero cannot be rejected, while restrictions that the included variables are equal to zero can be rejected.

Given the small size of the Saudi economy relative to the rest of the world, one might expect Saudi import prices to be exogenous to the Saudi economy. Actions internal to the Saudi economy may be expected to have limited impact on import prices and, by extension, on world prices. With one exception, that is the conclusion of the estimated equations. The exception is that oil prices did have an impact on import prices. This finding is consistent with the "global inflationary feedback mechanism" suggested by Rosser and Sheehan (1983). Simply stated, oil price increases have led to worldwide inflation which in turn has led to further oil price increases. OPEC and the Saudis may have attempted to increase the relative price of oil while the rest of the world has collectively inflated their economies (not necessarily as a matter of deliberate policy), thus returning the relative price of oil to approximately its previous value.[8/]

Saudi money growth is largely explained by the institutional structure of the Saudi economy. Saudi money is directly influenced only by Saudi exports which are in turn primarily oil based. This finding is consistent with Saudi monetary policy being determined in large measure by Saudi exports of oil. It makes more sense to talk of oil policy determining monetary policy than to talk of an independent monetary policy. This point is discussed in more detail in the next section. Again, the specification tests confirm the estimation results, and the reported specification tests are not sensitive to the lag lengths or included versus excluded variables.

The last equation, the export equation, indicates that Saudi exports are primarily determined by Saudi oil prices as well as by Saudi import prices. Neither of these findings should be surprising at this point. Saudi exports are primarily oil and oil derivatives. Thus, an increase in Saudi oil prices is expected to increase Saudi exports (depending, of course, on the elasticity of demand for Saudi oil). In addition, the direct impact of imported prices on Saudi exports is simply another manifestation of the global inflationary feedback mechanism. An increase in the price of Saudi imports leads to increases in Saudi oil prices as well as increases in Saudi exports. This result suggests that an increase in world inflation as seen by the Saudis will lead to an increase in oil prices as well as an increase in the quantity of oil exports. It should also be noted that seasonal dummy variables were originally included in all equations but are significant only in the Saudi export equation.

That oil prices and oil exports would be positively related is consistent with the apparent official thrust of Saudi oil policy since the initial large price increase of 1973. That is, the Saudi oil policy has acted as a countercyclical stabilizer in the global oil market. This has led them to increase production and exports when oil prices are rising as in 1979 and 1980 and to lower production and exports when oil prices are falling or weak as in 1977 and 1978 and in 1984 and 1985 also. Alternately, this finding may be due to Saudi Arabia's upward-sloping supply curve for oil.

The results discussed above mention only the direct impacts. For example, what impact does money have directly on inflation? They say nothing about the possible indirect effects. Following the suggestions of Sims (1980) and Fischer (1981), we subjected the estimated model to a series of sensitivity tests to ascertain not only the direct but also the indirect impacts of each variable on other variables in the system. This sensitivity analysis allows us to simulate the model's response to specific shocks in alternate variables over an extended period of time. The major purpose here is to expose the full interconnections between the variables as expressed in the complete model, in contrast to the linkages suggested simply by the individual equations.

The results of this analysis are summarized in table 2. The table states the response of each of the endogenous variables to a one standard deviation initial shock in each of the variables of the system. One difficulty with this approach involves the assignment of contemporary correlations and implicitly the ordering of the right-hand-side variables. The results presented in table 2 assume that all contemporaneous correlations equal zero. The simulation results in general are not sensitive to the choice of assumption.[9/] The table shows the impact of a one standard deviation change in each of the variables in the system on all of the other variables. The first column lists the percentage change in the endogenous variables after twenty quarters, while the second lists the percentage change after one hundred quarters. The latter column can be interpreted as approaching the "steady state" response to a given shock since there is very little change in the simulation results after that point.

A change in the Saudi consumer price index has significant impacts on both Saudi money and exports even though P appears as a significant dependent variable only in the oil price equation. This is but one example of the distinction between direct versus total impacts. Given the interactions in the model, Saudi inflation leads to increases in oil prices, exports and money. The impact of Saudi inflation on oil prices and exports is lessened somewhat over the longer time frame. Import prices remain virtually unchanged, as expected. In the steady state, there is virtually complete monetary accommodation. The Saudi money stock increases apace with Saudi inflation.

Oil prices are changed next. Clearly the model is very sensitive to an oil price shock, arguably excessively so. An increase in oil prices leads to large additional increases in oil prices. In fact, this type of behavior did characterize oil price behavior during this period. Oil prices increased substantially at certain discrete intervals. There is some question whether the model is stable. In fact, the model does eventually approach a steady state after 25 years. The long lags and potential instability are perhaps not as surprising now--given the significant recent reductions in oil prices and the disarray within OPEC--as they may have appeared even one year ago. In addition, the large magnitude of the oil price shock may also reflect the modeling of the Saudi economy without focusing on the supply and demand responses in the rest of the world to the oil price shock. Those responses surely provide some considerable limitations on Saudi oil price behavior. Thus, the results from changing oil prices should be discounted somewhat.

Unsurprisingly, the large changes in oil prices lead to large responses in the other variables. Exports rise dramatically, although after twenty quarters not by nearly as much as the increase in oil prices. After one hundred quarters, however, the response of exports and oil prices are virtually identical. This implies that there is no decline in the quantity of oil exports even with a price increase of 170 percent. This result demonstrates one danger inherent in any model--and perhaps particularly important with VAR models--of excluding potentially relevant variables. The alternative, modeling the rest of the world's reaction to an oil price increase, is beyond the scope of this paper. Oil price increases also significantly increase money growth and inflation, while import prices respond much less. The response of import prices is taken as an indicator of the response of world inflation to an increase in oil prices.

The model is also very responsive to an import price shock although not obviously unrealistically so. The increase in import prices leads to much greater increases in all the other variables in the system, increases all in excess of 10 percent. The model's responsiveness to imported prices is an indicator of the openness of the Saudi economy.

The response to a money shock is much more limited than the responses discussed above. Inflation increases somewhat in response, although by much less than the increase in the money stock. All other variables in the system remain basically unchanged. That the increase in the money stock significantly exceeds the increase in domestic inflation can be explained by an outflow of those funds from the Saudi economy.

Finally, a change in exports has significant impacts only on money growth and the rate of inflation. Again, this conclusion is in keeping with oil policy and oil exports primarily determining monetary policy with inflation responding directly to the monetary stimulus and indirectly to the increase in exports. Oil prices and import prices remain virtually unchanged in response to an export shock.

In general, inflation seems to be somewhat more responsive to external shocks, that is, to oil prices and import prices, than it is to internal shocks including money.

It should be noted again that the disparity in the responsiveness of the model to oil prices probably reflects the omission of global factors from the VAR model. This forcefully brings back the point that, while a vector autoregressive system is often alleged to be model independent, it is actually dependent on the choice of included versus excluded variables. Oil prices are clearly not simply a variable determined within this system, but rather should be embedded in a model of world oil supply and demand.

IV. Implications for the Saudi Economy

Is the vector autoregressive model consistent with the institutional realities of the Saudi economy? In general, most of the relationships appear consistent with a priori expectations. The main caveat involves excluded variables, most notably the global supply and demand for oil. Saudi Arabia may be the most important single actor in the oil market but it is by no means the only one. Non-Saudi political events such as the fall of the Shah of Iran or the effects of the Iran-Iraq war and economic events such as the recent decline in the demand for OPEC oil may be very important.

We now consider whether the above relationships are reasonable in light of the institutional structure of the Saudi economy. We begin by effectively partitioning the model into two subsystems. One includes oil prices and import prices which both appear in the long run to be relatively unaffected by the other variables in the system. Thus, they are considered basically exogenous to the Saudi economy in the long run. The other subsystem includes money growth and inflation and is endogenous to the Saudi economy in both the short run and the long run. Exports apparently represent the major link between the exogenous oil price-import price subsystem and the endogenous money-inflation subsystem.

Saudi inflation appears to affect the oil sector more through total exports than through oil prices. One possible explanation is that the Saudis adjust exports to respond to increased aggregate demand as reflected by the domestic inflation rate and that they adjust exports at least in part unsystematically with respect to price and quantity. Alternately, the Saudis may be partially constrained with respect to changes in oil prices and may change oil prices when possible and oil quantities when price changes would be politically expensive. The significance of exports has also been emphasized by Singer (1982).

A further consideration in this discussion arises from the significance of Saudi oil production and pricing policies for determining global oil prices and the increasing awareness of the Saudis of the significance of their actions for global financial stability. The stronger relationship from inflation to exports than from inflation to oil prices may, in fact, reflect two very different policy perspectives during the period of observation. It would appear that Saudi Arabia played a very different role in the oil price hike of 1973 than it did in that of 1979. In 1973 and the period immediately following, Saudi policy was to restrict oil production in order to force higher oil prices. The result was a rise in the value of exports due to higher oil prices during a period of domestic inflation. By 1979 the Saudi concern for global financial stability led to exactly the opposite policy, but with identical results for the value of exports. Saudi production was increased in order to restrain the global oil price increases arising from the decline in Iranian production after the fall of the Shah. Again the value of exports rose during a period of domestic inflation. Saudi oil policy in both cases responded to domestic as well as international pressures.

That exports cause money which in turn causes inflation is quite reasonable following a standard Hume specie-flow mechanism. We must keep in mind that the precise transmission involves export revenues passing into the economy from the government. Export revenues go to the Ministry of Finance and Economy which oversees and contains the chief monetary entity, SAMA. Thus, monetary policy is predicated on fiscal policy where those fiscal expenditures depend on oil export revenues. Aggregate government expenditures were originally included in the model but were dropped when they had no impact on any of the other variables in the system.[10/]

A major additional constraint upon the independence of SAMA with respect to the management and control of the money supply is the strict adherence of Saudi Arabia to the Hanbali

Sunni version of the Islamic Sharia law code which forbids interest rates.[11/] Although there is a three tiered structure of allowed interest rates in Saudi Arabia, the set of financial markets is, at best, incomplete. Indeed, Gerakis and Roncesvalles (1983) suggest that the most significant markets in Saudi riyals are probably those in Bahrain that are not directly controllable by SAMA. The embryonic financial markets are consistent with the continuing emphasis on cash and especially upon specie, which some believe is encouraged by certain Koranic passages. In any case, the monetary authorities lack both the relative independence and some policy tools available to the central banks of many other countries.

Any shifts of Saudi policy are likely to be in part a response to events in the global oil market and in the global macroeconomy that are not fully captured in the model considered here. This is probably most obvious when considering the responsiveness of the model to an oil price shock, although that response is eventually dampened. Indeed, another reason not to believe the responsiveness to oil prices is precisely that the oil price is itself perhaps the most important target variable of Saudi policymakers. Presumably, in the face of an upward spiral they would alter their policy--thus altering the structure of the model--to bring the spiral to a halt, if global forces did not do so first. Thus, the model should certainly not be considered a complete and perfect picture of the relationship between the Saudi and global economies.

It can be argued that during the period of observation there were major structural changes. While our results may be a spurious accident of the patterns of structural shifts, we believe the general plausibility of the results makes this unlikely. Lack of sufficient degrees of freedom precludes tests of this question.

V. Conclusions

A vector autoregressive model of Saudi inflation is developed with oil prices, import prices, exports and the money supply as the other variables in the system. Inflation is seen to be a direct function of import prices and the money supply. Saudi inflation is, however, indirectly responsive to all variables in the system.

Sensitivity analysis indicates the entire model is highly responsive to oil price shocks and to import price shocks. Given that oil prices are strongly influenced by Saudi policy, this suggests that the Saudis must take into account this sensitivity in their oil price policymaking. Furthermore, the links between oil prices, the import price index (presumably correlated with global inflation) and Saudi inflation suggest the possible existence of a "global inflationary feedback mechanism." Both of the above points suggest that it might be wise for the Saudis to pursue policy leading to a fair degree of oil price stability. It would appear that during the last several years this, in fact, has been the thrust of their policy.

FOOTNOTES

1/ See Blair (1976), Jacoby and Paddock (1980), Hamilton (1983b) and Burbidge and Harrison (1984).

2/ See Hudson and Jorgenson (1976), Hickman and Schleicher (1978), Darby (1982), Ray (1983), Hamilton (1983a), Burbidge and Harrison (1984) and Tatom (1981).

3/ See Klein (1978), Hickman and Schleicher (1978), Sheehan and Kelly (1984) and Tatom (1981).

4/ See Sims (1980), Fischer (1981) and McMillin and Fackler (1984).

5/ For a representative list of references see Hsiao (1981, 1982), Sims (1980), Fischer (1981), McMillin and Fackler (1984) Fackler (1985) and Litterman and Weiss (1985).

6/ Hijra 1401 corresponds to Gregorian 1980-81.

7/ The estimation interval ends in 1980 since the import price series is only available until then.

8/ An index of real Saudi crude oil prices measured by dividing OPI by CPI with 1975 = 100 rose from .31 in the first quarter of 1971 to 1.29 in the first quarter of 1974. It then fell to .76 by the final quarter of 1976 before rising to 1.91 by the final quarter of 1980. Since then it has again fallen.

9/ Given the technique of estimation, any assumption about the contemporaneous correlations would necessarily be arbitrary. Other assumptions about the contemporaneous correlations yield similiar results.

10/ Adding government spending and fiscal policy to the model yielded government spending a function of oil experts, as expected. No variables in the model were influenced by government spending. Thus the model estimated including government spending is not reported here.

11/ See Knauerhase (1975) and Looney (1982).

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Table 1
Specification Tests

Constraints	F-statistics	Degrees of freedom
$a_{11}(4) = 0$	2.05	4,29
$a_{12}(4) = 0$	1.65	4,29
$a_{13}(1) = 0$	8.18**	1,31
$a_{14}(2) = 0$	8.58**	2,31
$a_{15}(4) = 0$	1.34	4,29
$a_{21}(5) = 0$	2.77*	5,24
$a_{22}(1) = 0$	8.67**	1,24
$a_{23}(6) = 0$	6.80**	4,20
$a_{24}(4) = 0$	1.68	4,20
$a_{25}(4) = 0$	.68	4,20
$a_{31}(2) = 0$	1.27	2,29
$a_{32}(4) = 0$	6.94**	4,31
$a_{33}(1) = 0$	34.91**	1,31
$a_{34}(4) = 0$	.52	4,27
$a_{35}(4) = 0$	.57	4,27
$a_{41}(5) = 0$	2.28	5,15
$a_{42}(5) = 0$	1.07	5,15
$a_{43}(4) = 0$	1.39	4,16
$a_{44}(4) = 0$	6.61**	4,20
$a_{45}(9) = 0$	4.50**	9,20
$a_{51}(4) = 0$	.27	4,19
$a_{52}(5) = 0$	8.38**	5,23
$a_{53}(6) = 0$	4.05**	6,23
$a_{54}(4) = 0$	.24	4,19
$a_{55}(1) = 1$	10.66**	1,23

Table 2
Simulation Tests

	After 20 quarters		After 100 quarters
		Change in P	
P	6.2%		8.1%
O	3.6		1.4
I	.2		.2
M	2.8		8.9
X	5.2		3.0
		Change in O	
P	63.7%		134.5%
O	272.4		171.4
I	36.3		35.4
M	97.7		271.5
X	183.4		183.4
		Change in I	
P	11.9%		14.0%
O	11.0		8.2
I	3.8		4.0
M	20.9		26.9
X	13.7		14.0
		Change in M	
P	5.1%		4.7%
O	-.6		.0
I	.1		.0
M	14.8		12.8
X	-4.4		-1.2
		Change in X	
P	5.9%		8.2%
O	1.6		.0
I	.0		.0
M	17.1		18.8
X	11.3		12.1

APPENDIX

$$P(t) = \underset{(-.94)}{-.014} + \underset{(5.39)}{.476} \ast M(t-1) - \underset{(-1.32)}{.112} \ast M(t-2) + \underset{(1.56)}{.710} \ast I(t-1)$$

SE = .034 D.W. = 1.51 $\bar{R}^2 = .43$

$$O(t) = \underset{(.34)}{.014} + \underset{(2.83)}{.478} \ast O(t-1) + \underset{(.92)}{2.038} \ast I(t-1) + \underset{(.15)}{.426} \ast I(t-2)$$

$$+ \underset{(3.34)}{10.722} \ast I(t-3) - \underset{(-4.80)}{16.770} \ast I(t-5) + \underset{(1.88)}{5.696} \ast I(t-6)$$

$$+ \underset{(.88)}{.474} \ast P(t-1) - \underset{(-1.25)}{.580} \ast P(t-2) + \underset{(1.65)}{.783} \ast P(t-3)$$

$$+ \underset{(1.46)}{.688} \ast P(t-4) - \underset{(-2.71)}{1.442} \ast P(t-5)$$

SE = .241 Durbin's h = -.06 $\bar{R}^2 = .60$

$$I(t) = \underset{(2.64)}{.006} + \underset{(5.68)}{.734} \ast I(t-1) + \underset{(.37)}{.004} \ast O(t-1) + \underset{(.09)}{.001} \ast O(t-2)$$

$$+ \underset{(1.47)}{.015} \ast O(t-3) - \underset{(-3.51)}{.032} \ast O(t-4)$$

SE = .002 Durbin's h = .15 $\bar{R}^2 = .61$

$$M(t) = \underset{(-.37)}{-.008} - \underset{(-.26)}{.044} \ast M(t-1) + \underset{(.30)}{.049} \ast M(t-2) + \underset{(.32)}{.046} \ast M(t-3)$$

$$+ \underset{(3.85)}{.554} \ast M(t-4) + \underset{(1.08)}{.052} \ast X(t-1) - \underset{(-1.00)}{.049} \ast X(t-2)$$

$$+ \underset{(1.45)}{.073} \ast X(t-3) + \underset{(1.93)}{.102} \ast X(t-4) - \underset{(-.21)}{.012} \ast X(t-5)$$

$$+ \underset{(1.61)}{.084} \ast X(t-6) + \underset{(3.01)}{.145} \ast X(t-7) + \underset{(.84)}{.046} \ast X(t-8)$$

$$+ \underset{(1.72)}{.099} \ast X(t-9)$$

SE = .047 Durbin's h = .09 $\bar{R}^2 = .53$

$$
\begin{aligned}
X(t) = {} & \underset{(1.04)}{.046} - \underset{(-3.92)}{.816} * X(t-1) + \underset{(5.80)}{1.556} * O(t-1) - \underset{(-1.09)}{.194} * O(t-2) \\
& + \underset{(.12)}{.019} * O(t-3) - \underset{(-2.29)}{.396} * O(t-4) - \underset{(-1.27)}{.266} * O(t-5) \\
& + \underset{(.83)}{2.496} * I(t-1) + \underset{(.10)}{.346} * I(t-2) + \underset{(.38)}{1.206} * I(t-3) \\
& + \underset{(1.85)}{5.829} * I(t-4) - \underset{(-3.95)}{13.746} * I(t-5) + \underset{(3.23)}{9.598} * I(t-6) \\
& - \underset{(-.73)}{.042} * S1 - \underset{(-2.57)}{.165} * S2 - \underset{(-.68)}{.041} * S3
\end{aligned}
$$

SE = .229 Durbin's h = -.24 $\bar{R}^2 = 68$